IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of: **Shannon, et al.**	§	Serial No.: **10/823,364**
Filed: **April 12, 2004**	§	Confirmation No.: **4844**
Docket No.: **8756/ETCH/DICP**	§	Group Art Unit: **1792**
	§	Examiner: **Angadi, Maki A.**
For: **Plasma Control Using Dual Cathode Frequency Mixing**	§	

MAIL STOP APPEAL BRIEF - PATENTS
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

SUPPLEMENTAL APPEAL BRIEF

Appellants submit this Supplemental Appeal Brief to the Board of Patent Appeals and Interferences to correct a typo in the date submitted in the header and in the signature block. Specifically this, Brief is being filed March 10, and not on March 11. This Brief is otherwise substantively identical to the prior-filed, but misdated, Brief.

Appellants submit this Appeal Brief to the Board of Patent Appeals and Interferences on appeal from the decision of the Examiner of Group Art Unit 1792 dated October 11, 2007, rejecting claims 1-14 and 33-46.

As the Examiner re-opened prosecution before the Appeal was reviewed by the Board, the Applicants believe that the Appeal Brief fee of $500 previously paid on March 29, 2007 should be credited towards the present Appeal Brief. Accordingly, the Applicants believe that only the $10 difference between the present $510 Appeal Brief Fee and the $500 fee previously paid is due in connection with this paper. The Commissioner is hereby authorized to charge counsel's Deposit Account No. 50-3562 for this $10 fee, and for any additional fees required to make this paper timely and acceptable to the Office.

REAL PARTY IN INTEREST

The real party in interest is Applied Materials, Inc., located in Santa Clara, California.

RELATED APPEALS AND INTERFERENCES

The Appellants know of no related appeal and/or interference that may directly affect or be directly effected by or have a bearing on the Board's decision in the pending appeal.

STATUS OF CLAIMS

Claims 1-14 and 33-46 are pending in the application. Claims 15-32 have been cancelled. Claims 1-14 and 33-46 stand rejected as discussed below. All rejections of claims 1-14 and 33-46 as set forth in the Office Action dated October 11, 2007, and as noted blow, are appealed. The pending appealed claims are shown in the attached Appendix.

STATUS OF AMENDMENTS

An amendment to claim 12 was submitted in this application subsequent to final rejection. In the Advisory Action dated March 29, 2007, the Examiner indicated that the amendment would not be entered. Accordingly, the argument presented below with respect to claim 12 reflects the claim as presented without such amendment.

SUMMARY OF CLAIMED SUBJECT MATTER

The present invention provides methods of controlling characteristics of a plasma in a semiconductor substrate etch processing chamber using a dual frequency RF source. In the embodiment of independent claim 1, a method of controlling characteristics of a plasma (110) in a semiconductor substrate etch processing chamber (100) using a dual frequency RF source (122, 123) includes supplying a first RF signal to a first electrode (127) disposed in an etch chamber (102); and supplying a second RF signal to the first electrode (127), wherein an interaction between the first and second RF signals is used to control at least one characteristic of a plasma (110) formed in the

etch chamber. (*See, e.g., Specification*, ¶¶[0015]-[0016], [0019], [0023], [0029]-[0031]; Figs. 1, 3.)

In the embodiment of independent claim 34, a method of controlling characteristics of a plasma in a semiconductor substrate etch chamber using a dual frequency RF source includes determining a desired energy distribution of the plasma (110); and producing the desired energy distribution through a controlled interaction between a first and a second RF signal applied to a first electrode (127) disposed in an etch chamber (102). (*See, e.g., Specification*, ¶¶[0015]-[0016], [0019], [0023], [0034]-[0035]; Figs. 1, 4.)

In the embodiment of independent claim 37, a method of controlling characteristics of a plasma in a semiconductor substrate etch chamber using a dual frequency RF source includes supplying a first RF signal at a first power level to a first electrode (127) disposed in an etch chamber (102); and controlling the application of a second RF signal at a second power level to the first electrode (127) to produce a desired power distribution in the plasma. (*See, e.g., Specification*, ¶¶[0015]-[0016], [0019], [0023], [0034]-[0035]; Figs. 1, 4.)

GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

1. Claims 1-3 and 10 stand rejected under 35 USC. §103 as being unpatentable over U.S. Patent Application Publication No. 2003/0127319 to *Demaray, et al.* (hereinafter *Demaray*).

2. Claims 40-42 stand rejected under 35 USC §103 as being unpatentable over *Demaray*, as applied to claim 1 above, in further view of U.S. Patent Application Publication No. 2003/0148611 to *Dhindsa et al.* (hereinafter *Dhindsa*).

3. Claims 4-9, 11 and 12 stand rejected under 35 USC §103 as being unpatentable over *Demaray*, as applied to claims 1-3, and 10 above, and in further view of *Georgieva et al.,* Journal of Applied Physics, V. 94, No. 6, Sept. 15, 2003, pgs 3748-3756 (hereinafter *Georgieva*).

4. Claim 13 stands rejected under 35 USC §103 as being unpatentable over *Demaray* in view of *Georgieva*, as applied to claims 10-12 above, and in further view of

Lieberman et al. (Plasma Sources Sci. Technol., 11 (2002), pages 283-293) (hereinafter *Lieberman*).

5. Claim 33 stands rejected under 35 USC §103 as being unpatentable over *Demaray*, as applied to claim 1 above, in view of *Georgieva* and *Lieberman*.

6. Claim 14 stands rejected under 35 USC §103 as being unpatentable over *Demaray* in view of *Georgieva*, as applied to claims 10-12, and in further view of *Dhindsa*.

7. Claims 34-35 and 37-39 stand rejected under 35 USC §103 as being unpatentable over *Dhindsa* in view of *Lieberman*.

8. Claim 36 stands rejected 35 USC §103 as being unpatentable over *Dhindsa* in view of *Lieberman*, as applied to claim 34, and in further view of *Demaray* and *Georgieva*.

9. Claims 43-46 stand rejected under 35 USC §103 as being unpatentable over *Dhindsa* in view of *Lieberman*.

ARGUMENT

1. 35 USC §103 Claims 1-3 and 10

Claims 1-3 and 10 stand rejected under 35 USC. §103 as being unpatentable over *Demaray*. The Appellants disagree.

Claim 1

Independent claim 1 recites limitations not taught, suggested, or otherwise obtainable by any combination of the cited art. *Demaray* discloses a physical vapor deposition (PVD) process utilizing "radio frequency (RF) sputtering of a wide target in the presence of a sputtering gas under a condition of uniform target erosion." (*Demaray,* p. 1, ¶ [0009].) The RF sputtering process may be a dual frequency RF sputtering process, in which a low frequency RF power is applied to the target to bombard a substrate with ions from the plasma and in which a higher frequency RF power is applied to the target to accelerate electrons in the plasma and sputter the target material. (*Id.*, p. 5, ¶ [0043].)

However, *Demaray* fails to teach or suggest any interaction between the first and second RF signals applied to the target – *Demaray* merely discloses that each signal is

utilized to provide independent benefits in the disclosed PVD process and is silent with respect to any effect that may occur due to any interaction between the two RF signals applied to the target.

Moreover, in addition to failing to teach or suggest that an interaction between the two RF signals may have an effect on the plasma, *Demaray* further and *a fortiorari* fails to teach or suggest that control of such an interaction may be utilized to control any characteristics of the plasma. As discussed above, *Demaray* teaches that each RF signal is utilized to provide independent benefits with respect to the disclosed process. In fact, the Examiner admits this teaching in subsequent portions of the present Office Action. (*see, e.g., Office Action dated 10/11/07*, p. 8, ll. 8-10, "The higher frequency controls electron/ion density the lower frequency controls ion bombardment (through the sheath or DC potential) according to Demaray.")

Accordingly, *Demaray* fails to teach or suggest supplying a first RF signal to a first electrode disposed in an etch processing chamber; and supplying a second RF signal to the first electrode, wherein an interaction between the first and second RF signals is used to control at least one characteristic of a plasma formed in the etch processing chamber, as recited in claim 1.

In the Response to Arguments section of the Final Office Action, during an interview with Examiners Angadi and Tran on February 6, 2007, in the Advisory Action dated March 29, 2007, and in the Response to Arguments section of the present Office Action, the Examiner continuously and exclusively cites *Demaray* paragraph [0043] to maintain the rejection of the present claims. Moreover, the Examiner's comments do not appear to address the above discussion that Demaray teaches to apply two different RF signals to provide independent benefits in the disclosed PVD process and is silent with respect to any effect that may occur due to any interaction between the two RF signals applied to the target..

In fact, in the Response to Arguments section of the present Office Action, the Examiner again states, in reference to a combined teaching of *Demaray* and *Dhindsa*, that "high frequency accelerates electrons in the plasma, which is not efficient at accelerating the much slower heavy ions in the plasma. Adding a slow frequency, according to Demaray causes ions in the plasma to bombard the film being deposited

on the substrate, resulting in sputtering and densification of the film." (*Office Action dated 10/11/07*, p. 15, ll. 7-11.) This is in agreement with the above discussion that *Demaray* teaches utilizing two different RF signals to provide <u>independent</u> benefits in the disclosed PVD process and is silent with respect to any effect that may occur due to any interaction between the two RF signals applied to the target.

The Examiner further asserts that "the first and second frequency RF power signals are involved in a dynamic process to optimize the characteristics of the plasma and hence the deposition or etch conditions" and places a citation to *Demaray*, paragraph 0043 directly thereafter, However, the preceding sentence is merely an assertion by the Examiner as the cited paragraph of Demaray does not refer to any "dynamic process" that "the first and second frequency RF power signals are involved in… to optimize the characteristics of the plasma," as asserted by the Examiner. Even assuming, arguendo, that what the Examiner asserts is true, Demaray still fails to appreciate that there is any specific interaction between the first and second frequency RF power signals that may be specifically controlled, and instead teaches to utilize the first and second frequency RF power signals to provide independent control of different plasma characteristics. Thus, as noted above, the cited portion of *Demaray* – as well as the Examiner's comments in the Office Action and the Response to Arguments section – relates to <u>independent</u> control of <u>different</u> plasma characteristics and not to control of any plasma characteristic via an interaction between two RF signals applied to a single electrode, as recited in the claims.

In fact, the Examiner has not cited any plasma characteristics that are controlled by any interactions between the two RF signals applied to the target in *Demaray*. The Examiner does, for example, list plasma characteristics such as plasma density, ion density, ion bombardment, and electron acceleration (*see, e.g., Advisory Action* dated March 29, continuation sheet, citing *Demaray*, ¶[0043]). However, as noted above and as agreed to by the Examiner in other portions of the previous and present Office Actions, the cited portion of *Demaray* teaches that the high frequency signal is utilized for one purpose (to accelerate electrons in the plasma) and the low frequency signal is utilized for an second, independent purpose (to cause ions in the plasma to bombard the film being deposited on the substrate). The cited portion of *Demaray* does not teach

or suggest either, 1) an effect on the plasma caused by interaction between the two RF signals; or 2) control of that effect on the plasma via control over the interaction between the two RF signals.

Accordingly, *Demaray* fails to teach or suggest that an interaction between the first and second RF signals is used to control at least one characteristic of a plasma formed in the etch processing chamber, as recited in claim 1. As such, a *prima facie* case of obviousness has not been established because *Demaray* fails to teach or suggest the limitations recited in claim 1. Thus, claim 1, and all claims depending therefrom, are patentable over *Demaray*.

Claim 2

With respect to claim 2, the Appellants respectfully disagree with the Examiner's rejection. The Examiner contends that the teachings of *Demaray* read on Applicant's claim "where the dual frequency causes a sheath modulation." (*Office Action*, p. 4, citing *Demaray* ¶¶ [0043] and [0047].) However, claim 2 does <u>not</u> recite that the dual frequency causes a sheath modulation, as asserted by the Examiner. Claim 2 further limits claims 1 by reciting, "wherein the plasma characteristic [controlled by the interaction between the first and second RF signals] is at least sheath modulation."

In addition, the portions of *Demaray* cited by the Examiner relate to different aspects of the PVD process. Specifically, paragraph [0043] relates to the effects of the dual frequencies applied to the PVD target, while paragraph [0047] discusses the plasma sheath formed when a bias power is applied to a substrate. As such, although *Demaray* may teach that a bias power may be applied to form a plasma sheath, *Demaray* still fails to teach or suggest that an interaction between two RF signals may be used to control the plasma sheath.

Thus, *Demaray* not only fails to teach or suggest any interaction between the first and second RF signals, but further fails to teach or suggest that any interaction between the first and second RF signals have any effect on the plasma sheath. Accordingly, *Demaray* fails to teach or suggest that any interaction between the first and second RF signals is used to control at least sheath modulation of the plasma, as recited by claim 2.

Moreover, in the Response to Arguments section of the Final Office Action and the present Office Action, the Examiner admits that *Demaray* teaches that "the sheath formation in the chamber is due to application of bias to the substrate." While the Examiner notes that this is akin to applying a low frequency RF signal to the high frequency signal, *Demaray* clearly teaches that the application of the separate bias signal is what is used to create the plasma sheath about the substrate (*Demaray*, ¶ [0047]), Accordingly, regardless of whether sheath formation in the chamber due to application of a substrate bias is "akin" to the effect of adding the low frequency RF power to the high frequency power to the source, *Demaray* still fails to teach or suggest that an interaction between two RF signals may be used to control sheath modulation of the plasma. Thus, *Demaray* further fails to teach or suggest controlling the sheath modulation of the plasma through an interaction between two RF signals applied to an electrode disposed in an etch chamber, as recited in claim 2.

As such, a *prima facie* case of obviousness has further not been established because *Demaray* fails to teach or suggest the limitations recited in claim 2. Thus, claim 2 is further patentable over *Demaray*.

Claim 10

With respect to claim 10, the Appellants respectfully disagree with the Examiner's rejection. Specifically, the Examiner states that *Demaray* uses "dual frequency for the target to improve film characteristics as well as film uniformity which is an attribute of power distribution uniformity," citing *Demaray*, ¶[0023]. (*Office Action dated 10/11/08*, p. 5, ll. 5-7.)

However, *Demaray* teaches to deposit a uniform film through a uniform target erosion obtained in one of two disclosed ways: diode sputtering, or a magnetron sputtering process. (*Demaray*, p. 3, ¶¶ [0029]-[0030].) *Demaray* fails to teach or suggest controlling the power distribution within the plasma, let alone controlling the power distribution within the plasma via an interaction between the first and second RF signals. Accordingly, *Demaray* fails to teach or suggest that any interaction between the first and second RF signals is used to control at least a power distribution within the plasma, as recited by claim 10.

In the Response to Arguments section of the Office Action, the Examiner asserts that paragraph [0043] of *Demaray* teaches to use the first and second RF frequencies and modulating the flow of charge carriers to control the power distribution in the plasma. However, the Appellants note that the cited portion of *Demaray* teaches applying a high frequency signal for sputtering the target and applying a low frequency signal to cause ions in the plasma to bombard the film being deposited on the substrate, and fails to teach or suggest an interaction between the first and second RF signals is used to control the power distribution in the plasma, as recited in claim 10. Accordingly, a *prima facie* case of obviousness has further not been established with respect to claim 10, as the cited reference fails to teach or suggest all the limitations recited in the claim. Thus, claim 10 is further patentable over *Demaray*.

Thus, the Appellants submit that claims 1-3 and 10 are patentable over *Demaray*. Accordingly, the Appellants respectfully request that the rejection be withdrawn and the claims allowed.

<u>2. 35 USC §103 Claims 40-42</u>

Claims 40-42 stand rejected under 35 USC §103 as being unpatentable over *Demaray*, as applied to claim 1 above, in further view of *Dhindsa*. The Appellants disagree.

Independent claim 1, from which claim 40 depends, recites limitations not taught or suggested by the combination of the cited art. The patentability of claim 1 over *Demaray* as discussed above. The Examiner admits in the present Office Action that *Demaray* fails to disclose the disposition of a first electrode below the substrate support surface and asserts that the teachings of Dhindsa would lead one of ordinary skill in the art to modify Demaray to apply the dual frequencies to an electrode disposed beneath the substrate. (*Office Action dated 10/11/08*, p. 5, l. 13 – p. 6, l. 2.)

However, *Demaray* teaches to apply two RF signals to a target in a PVD chamber and modifying *Demaray* in the manner suggested by the Examiner to instead apply the two RF signals to an electrode disposed beneath the substrate would impermissibly change the principle of operation of *Demaray* and further make the apparatus unsuitable for its intended purpose.

In addition, *Dhindsa* discloses a dual electrode processing chamber, utilizing confinement rings, a focus ring, and a shield, wherein a chuck 202 (first electrode), disposed beneath a semiconductor wafer 204, is coupled to a dual frequency RF power source 206. Dhindsa specifically teaches that equipotential field lines set up over the wafer 204 by the RF power supplied by the dual frequency RF power source 206 may not be uniform and may vary significantly at the edge of the wafer 204. (*Dhindsa*, p. 2, ¶ [0026].) Accordingly, *Dhindsa* teaches that the "presence of the focus ring [and the confinement rings] allows the equipotential field lines to be disposed substantially uniformly over the entire surface of the wafer." (*Id.*) *Dhindsa* further discloses that the "presently-claimed configuration," including the focus ring, confinement rings, and shield, is required to achieve substantially improved etch rate uniformity. (*Id.*, p. 3, ¶ [0036]).

Thus, while *Dhindsa* may disclose certain apparatus and methods for controlling etch rate uniformity, *Dhindsa* fails to teach or suggest a modification of *Demaray* that would result in a method wherein an interaction between the first and second RF signals is used to control at least one characteristic of a plasma formed in the etch chamber, as recited in claim 1, from which claim 40 depends. As such, a *prima facie* case of obviousness has not been established with respect to claim 40, as the cited references fails to teach or suggest all the limitations recited in the claim.

Thus, claim 40, and claims 41-42, depending therefrom are patentable over *Demaray* in view of *Dhindsa.* Accordingly, the Appellants respectfully request that the rejection be withdrawn and the claims allowed.

<u>3. 35 USC §103 Claims 4-9, 11 and 12</u>

Claims 4-9, 11 and 12 stand rejected under 35 USC §103 as being unpatentable over *Demaray* as applied to claims 1-3, 10 above, and in further view of *Georgieva*. The Appellants disagree.

Independent claim 1, from which claims 4-9 and 11-12 depend, recites limitations not taught or suggested by any permissible combination of the cited art. The patentability of claim 1 over *Demaray* is discussed above. *Georgieva* is cited to assert various effects of dual frequency RF on a plasma. *Georgieva* generally compares

single frequency processing to a dual frequency processing. Specifically, *Georgieva* discloses potential and electric field distributions, electron and ion density distributions, and electron and ion energy distributions for single and dual frequency plasma processing. However, *Georgieva* fails to teach or suggest that an interaction between the frequencies (as compared to the individual frequencies themselves) applied in a dual frequency chamber may be utilized to control plasma properties.

As such, *Georgieva* fails to teach or suggest a modification to the teachings of *Demaray* that would yield the limitations recited in claim 1. Therefore, a *prima facie* case of obviousness has not been established as the combination of the cited references fails to yield the limitations recited in the claims. Thus, claims 4-9 and 11-12 are patentable over the combination of *Demaray* and *Georgieva*.

Claims 4-6

Moreover, with respect to claim 4, the Examiner asserts that "with the proper choice of the above parameters, one of ordinary skill in the art would be able to obtain an IEDF of any desired shape...." However, the Appellants note that in order to satisfy the burden of creating a *prima facie* case of obviousness, there must be some motivation or suggestion in the cited references, or in the general knowledge available to one of ordinary skill in the art at the time the invention was made, to modify the reference(s) in a manner that would yield the claimed invention. (*MPEP* §2142, citing *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).) "The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination." (*MPEP* §2143.01 III, citing *In re Mills*, 916 F.2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990) (emphasis in original).)

In this instance, a *prima facie* case of obviousness has further not been established as the Examiner has not provided a motivation, suggestion, or other line of reasoning as to why one of ordinary skill in the art would combine the references in a manner that would yield the limitations recited in claim 4. The Examiner has similarly not provided any motivation or reasoning to modify *Demaray* in view of *Georgieva* with respect to the limitations recited in claims 5-6. In addition, with respect to claim 6, as noted in the Response to Final Office Action submitted February 28, 2007 and in the

Appeal Brief filed March 29, 2007, the Appellants rely on the plain meaning of the term "peak-to-peak" sheath voltage and submit that no special definition is required.

Therefore, a *prima facie* case of obviousness has further not been established as the combination of the cited references fails to yield the limitations recited in claims 4-6. Thus, claims 4-6 are further patentable over the combination of *Demaray* and *Georgieva*.

Claim 9

With respect to claim 9, the Appellants note that the third RF signal 18 of *Demaray* (cited by the Examiner as used to form the plasma) is only taught by *Demaray* as utilized for providing a substrate bias and not for forming a plasma. *Demaray* teaches to use RF generator 14 to apply power to the target 12 to generate a plasma. (Demaray, ¶ [0039].) As such, *Demaray* fails to teach or suggest supplying a third RF signal to a second electrode to form the plasma, as recited in claim 9.

Therefore, a *prima facie* case of obviousness has further not been established as the combination of the cited references fails to yield the limitations recited in claim 9. Thus, claim 9 is further patentable over the cited art as the combination of *Demaray* and *Georgieva* fails to yield the limitations recited in the claims.

Claims 11-12

With respect to claims 11-12, the Examiner asserts in the Response to Arguments section of the present Office Action that "Georgieva presents extensive simulation results of the potential and electric-field distribution in the single and dual-frequency regime." (*Office Action dated 10/11/08*, p. 15, ¶ (e).) However, the Appellants note that Figures 2-3 of *Georgieva* merely depict potential and electric field distributions as a function of phase (time) and position (distance from the driven electrode) for a single frequency (Figure 2) and from a dual frequency (Figure 3) chamber. (*Georgieva*, p. 3752, ll. 12-14; Figs. 2-3.) These Figures of *Georgieva* (and corresponding text) fails to teach or suggest how spatial distributions may vary as a function of frequency. Accordingly, *Georgieva* fails to teach or suggest a modification to the teachings of *Demaray* that would result in a process wherein the first and second RF signals provide similar plasma excitation properties and different spatial uniformity profiles, as recited in claim 11.

In addition, *Georgieva* fails to discuss the results of any interaction between the two RF signals over a range of frequencies and/or power ratios. Moreover, *Georgieva* further fails to discuss the results any such interaction between the two RF signals may have on the power distribution in the plasma. Accordingly, *Georgieva* further fails to teach or suggest a modification to the teachings of *Demaray* that would result in a process wherein the interaction between the first and second RF signals is a varying effect on the power distribution in the plasma, as recited in claim 12.

Therefore, a *prima facie* case of obviousness has further not been established as the combination of the cited references fails to yield the limitations recited in claims 11-12. Thus, claims 11-12 are further patentable over the cited art as the combination of *Demaray* and *Georgieva* fails to yield the limitations recited in the claims.

Thus, the Appellants submit that claims 4-9 and 11-12 are patentable over *Demaray* in view of *Georgieva*. Accordingly, the Appellants respectfully request that the rejection be withdrawn and the claims allowed.

<u>4. 35 USC §103 Claim 13</u>

Claim 13 stands rejected under 35 USC §103 as being unpatentable over *Demaray* in view of *Georgieva*, as applied to claims 10-12 above, and in further view of *Lieberman*.

Independent claim 1, from which claim 13 depends, recites limitations not taught or suggested by any permissible combination of the cited art. The patentability of claim 1 over *Demaray* in view of *Georgieva* is discussed above. *Lieberman* is cited to show that radial plasma electric field distribution is different for varying frequencies. However, *Lieberman* fails to teach or suggest supplying a first RF signal to a first electrode disposed in an etch processing chamber and supplying a second RF signal to the first electrode, wherein an interaction between the first and second RF signals is used to control at least one characteristic of a plasma formed in the etch processing chamber, as recited in claim 1. Accordingly, *Lieberman* fails to teach or suggest a modification to the combination of *Demaray* in view of *Georgieva* that would yield the limitations recited in claim 1. Thus, a *prima facie* case of obviousness has not been established as the combination of the cited references fails to yield the limitations recited in the claims.

Furthermore, with respect to claim 13, the Examiner asserts that "it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the method of *Demaray* to obtain even higher uniformity by <u>selecting the proper parameters for the plasma</u> <u>and combining complementary first and second frequencies energy distributions</u> to obtain an net radial power distribution that is substantially uniform." (*Final Office Action*, p. 8, ll. 12-16) (emphasis added). However, no cited reference or line of reasoning provided by the Examiner teaches or suggests how selecting or controlling the proper parameters for the plasma may be performed or may result in "complementary first and second frequencies energy distributions."

Moreover, the Appellants disagree with the Examiner's assertion that *Lieberman* teaches how spatial power distribution depends upon frequency and that one of ordinary skill in the art would be motivated to modify *Demaray* with the teachings of *Lieberman* "in order to obtain a highly uniform process area... by combining two frequencies with complementing energy or power distributions." (*Office Action dated 10/11/08*, p. 10, ll. 4-6.)

Lieberman provides only two examples of frequencies (13.56 MHz and 40.7 MHz). (*Lieberman*, Figs. 4-15, and accompanying text.) While *Lieberman* shows that the resultant power distributions are not the same for these frequencies, *Lieberman* in no way teaches or suggests that either these frequencies, or any other combinations of frequencies may be complementary or may be combined to form a net power distribution that is substantially uniform, as asserted by the Examiner. Specifically, *Lieberman* does not discuss how the power distribution varies over a range of frequencies. Furthermore, *Lieberman* does not discuss resultant power distributions that may occur upon applying multiple frequencies to a single electrode. Accordingly, *Lieberman* fails to provide any teaching or suggestion that would allow one of ordinary skill in the art to modify the teachings of *Demaray* to yield a method wherein the first and the second RF signals are selected such that a combined effect of the first and second RF signals produces a substantially flat power distribution, as recited in claim 13.

Thus, the Appellants submit that claim 13 is patentable over *Demaray* in view of *Georgieva* and in further view of *Lieberman*. Accordingly, the Appellants respectfully request that the rejection be withdrawn and the claims allowed.

<u>5. 35 USC §103 Claim 33</u>

Claim 33 stands rejected under 35 USC §103 as being unpatentable over *Demaray,* as applied to claim 1 above, in view of *Georgieva* and *Lieberman*. The Appellants disagree.

Independent claim 1, from which claims 33 depends, recites limitations not taught or suggested by any permissible combination of the cited art. The patentability of claim 1 over *Demaray* in view of *Georgieva* and *Lieberman* is discussed above. With respect to claim 33, the Examiner asserts that one of ordinary skill in the art would be motivated to optimize the two frequencies through routine experimentation. The Applicant's disagree. As the Examiner is aware, optimization through routine experimentation is only a permissible basis for rejection where the parameter to be "optimized" is a results effective variable. (*MPEP* §2144.05.II.B.)

Here, the Examiner notes that each of *Demaray*, *Georgieva*, and *Lieberman* disclose different frequencies. However, none of the cited references teaches or suggests that the selected frequencies may be varied to provide any specific result. Moreover, none of the cited references teaches or suggests that the selected frequencies may be varied to provide an interaction that controls characteristics of a plasma. Accordingly, none of the references teach or suggest that the selection of the frequencies is a results effective variable, as required to assert the basis of rejection applied by the Examiner. As such, a *prima facie* case of obviousness has not been established with respect to claim 33 as there is no motivation to combine the references in the manner asserted by the Examiner.

Thus, the Appellants submit that claim 33 is patentable over *Demaray* in view of *Georgieva* and *Lieberman*. Accordingly, the Appellants respectfully request that the rejection be withdrawn and the claims allowed.

6. 35 USC §103 Claim 14

Claim 14 stands rejected under 35 USC §103 as being unpatentable over *Demaray* in view of *Georgieva,* as applied to claims 10-12, and in further view of *Dhindsa*.

Claim 1, from which claim 14 depends, recites limitations not taught or suggested by any combination of the cited art. The patentability of claim 1 over the combination of *Demaray* in view of *Georgieva* is discussed above. The teachings of *Dhindsa* have been discussed above. As relevant here, *Dhindsa* is cited to allegedly show two RF signals coupled to a cathode and to provide control for plasma uniformity. (Office Action dated 10/11/07, p. 11, ll. 19-22.) However, as noted above, *Dhindsa* teaches that equipotential field lines set up over the wafer 204 by the RF power supplied by the dual frequency RF power source 206 may not be uniform and may vary significantly at the edge of the wafer 204. (*Dhindsa*, p. 2, ¶ [0026].) According to *Dhindsa* the focus ring and confinement rings are utilized to allow the equipotential field lines to be disposed substantially uniformly over the entire surface of the wafer. (*Id.*) *Dhindsa* further discloses that the "presently-claimed configuration," including the focus ring, confinement rings, and shield, is required to achieve substantially improved etch rate uniformity. (*Id.*, p. 3, ¶ [0036]).

Thus, while *Dhindsa* may disclose certain apparatus and methods for controlling etch rate uniformity, *Dhindsa* fails to teach or suggest a method wherein an interaction between the first and second RF signals is used to control at least one characteristic of a plasma formed in the etch chamber, as recited in claim 1, or wherein the interaction between the first and second RF signals is used to control the uniformity of a plasma enhanced etch process, as recited in claim 14. Accordingly, a *prima facie* case of obviousness has not been established because *Dhindsa* fails to teach or suggest a modification to the teachings of the combination of *Demaray* and *Georgieva* in a manner that would yield the limitations recited in the claims.

Moreover, obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either explicitly or implicitly in the references themselves or in the knowledge generally available to one of ordinary skill in

the art. (*MPEP* §2143.01.) Here, the Examiner fails to assert any teaching, suggestion, or motivation to combine the cited references. The Examiner cites it would be obvious to use the method of *Dhindsa* to control the uniformity of an etch process because *Dhindsa* discloses such a method. However, as noted above, *Dhindsa* discloses a <u>different</u> method for controlling an etch process and fails to teach or suggest a modification of the primary references in a manner that would yield the limitations recited in the claims. As such, a *prima facie* case of obviousness has not been established because the combination of the cited references fails to yield the limitations recited in claim 14 and further because no motivation exists for the modification proposed by the Examiner.

Thus, the Appellants submit that claim 14 is patentable over *Demaray* in view of *Georgieva* and in further view of *Dhindsa*. Accordingly, the Appellants respectfully request that the rejection be withdrawn and the claim allowed.

<u>7. 35 USC §103 Claims 34-35 and 37-39</u>

Claims 34-35 and 37-39 stand rejected under 35 USC §103 as being unpatentable over *Dhindsa* in view of *Lieberman*. The Appellants respectfully disagree.

The teachings of both *Dhindsa* and *Lieberman* are discussed above. Neither *Dhindsa* nor *Lieberman*, alone or in combination teach or suggest all of the limitations recited in either of independent claims 34 or 37. Specifically, the cited references do not suggest or teach determining a desired energy distribution of the plasma and producing the desired energy distribution through a controlled interaction between a first and a second RF signal applied to a first electrode disposed in a processing chamber, as recited in claim 34, or supplying a first RF signal at a first power level to a first electrode disposed in an etch chamber and controlling the application of a second RF signal at a second power level to the first electrode to produce a desired power distribution in the plasma, as recited in claim 37.

The Examiner supports the obviousness rejection by stating that one of ordinary skill in the art would be motivated to modify the teachings of *Dhindsa* with those of *Lieberman* by combining "an effect which yields a center low energy distribution with an effect that yields a center high energy distribution in order to obtain a resulting

substantially flat uniform energy or power distribution." The Appellants respectfully disagree.

Although *Lieberman* provides examples of energy distributions formed from 13.56 and 40.7 MHz signals, *Lieberman* fails to teach or suggest "a center low energy distribution" and "a center high energy distribution," as suggested by the Examiner. Furthermore, *Lieberman* fails to teach or suggest what the resultant energy distribution would be for any combination of frequencies applied to a single electrode. Accordingly, *Lieberman* fails to teach or suggest the modification proposed by the Examiner. As such, a *prima facie* case of obviousness has not been established as the combination of the cited references fails to yield the limitations recited in the claims.

The Examiner further contends that one skilled in the art would be motivated to optimize through routine experimentation of the power ratio between the two signals, citing *MPEP* §2144.05(II)(B). However, as the Examiner is aware, "[a] particular parameter must first be recognized as a result-effective variable... before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation." (*Id.*, citing, *In re Antonie*, 559 F.2d 618, 195 USPQ 6 (CCPA 1977).) In this instance, the power ratio between the two RF signals is not taught or suggested by any of the cited references to be a results effective variable. As such, per the case law cited in *MPEP* §2144.05(II)(B), the power ratio between the two RF signals is not optimizable through routine experimentation, as asserted by the Examiner. Accordingly, claims 34-35 and 37-39 are further patentable over the cited art.

Thus, the Appellants submit that claims 34-35 and 37-39 are patentable over *Dhindsa* in view of *Lieberman*. Accordingly, the Appellants respectfully request that the rejection be withdrawn and the claims allowed.

8. 35 USC §103 Claim 36

Claim 36 stands rejected under 35 USC §103 as being unpatentable over *Dhindsa*, in view of *Lieberman*, and in further view of *Demaray* and *Georgieva*. The Appellants respectfully disagree.

Independent claim 34, from which claim 36 depends, recites limitations not taught or suggested by any permissible combination of the cited art. The patentability of claim 34 over *Dhindsa* in view of *Lieberman* is discussed above. Each reference discloses providing a specific set of frequencies by a dual frequency power source: *Dhindsa* (2MHz and 27 MHz), *Georgieva* (27 MHz and 2MHz), Demaray (13.56 MHz and 100-400 KHz) and *Lieberman* (13.56 MHz and 40.7 MHz).

No combination of the cited references teach or suggest applying about a 2 MHz frequency and about a 13.56 MHz frequency from a first and second RF source, respectively, to a first electrode, as recited in claim 36. The Examiner supports this rejection by stating "one who is skilled in the art would be motivated to optimize through routine experimentation of frequency mixing using commercially available RF power supplies." (*Final Office Action*, p. 12, ll. 20-22.)

However, as previously noted, only results effective variables may be said to be optimizable through routine experimentation. (*MPEP* §2144.05(II)(B).) Here, as discussed above, there is no teaching or suggestion that the particular frequencies as recited in the claims are results effective variables. Moreover, as the controlling mechanism recited in the claims is an interaction between the two frequencies (which is further not taught or suggested by the cited art), it is further not taught or suggested that an interaction between the two frequencies is a variable that may by optimized through routine experimentation.

Therefore, a *prima facie* case of obviousness has not been established as the combination of the cited references fails to yield first determining a desired energy distribution of the plasma and then producing the desired energy distribution through a controlled interaction between a first and a second RF signal applied to a first electrode disposed in a processing chamber, wherein the first RF signal has a frequency of about 2 MHz and the second RF signal has a frequency of about 13.56 MHz as recited by claim 36.

Thus, the Appellants submit that claim 36 is patentable over *Dhindsa* in view of *Lieberman*, *Georgieva*, and *Demaray.* Accordingly, the Appellants respectfully request that the rejection be withdrawn and the claim allowed.

9. 35 USC §103 Claims 43-46

Claims 43-46 stand rejected under 35 USC §103 as being unpatentable over *Dhindsa* in view of *Lieberman.*

Independent claims 34 and 37, from which claims 43-46 respectively depend, each recite limitations not obtainable by the combination of the cited art. The patentability of claims 34 and 37 over *Dhindsa* in view of *Lieberman* has been discussed above. As such, claims 43-46 are patentable over *Dhindsa* in view of *Lieberman* for the same reasons.

Specifically, as discussed above, the combination of *Dhindsa* and *Lieberman* fails to teach or suggest determining a desired energy distribution of the plasma and producing the desired energy distribution through a controlled interaction between a first and a second RF signal applied to a first electrode disposed in a processing chamber, as recited in claim 34, or supplying a first RF signal at a first power level to a first electrode disposed in an etch chamber and controlling the application of a second RF signal at a second power level to the first electrode to produce a desired power distribution in the plasma, as recited in claim 37. As such, a *prima facie* case of obviousness has not been established as the combination of the cited references fails to yield the limitations recited in the claims.

Thus, the Appellants submit that claims 43-46 are patentable over *Dhindsa*, in view of *Lieberman*. Accordingly, the Appellants respectfully request that the rejection be withdrawn and the claims allowed.

CONCLUSION

For the reasons advanced above, Appellants respectfully urge that the rejections of claims 1-14 and 33-46 as being unpatentable under 35 U.S.C. §103 are improper. Reversal of the rejections in this appeal is respectfully requested.

Respectfully submitted,

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CLAIMS APPENDIX

1. (Previously Presented) A method of controlling characteristics of a plasma in a semiconductor substrate etch processing chamber using a dual frequency RF source, comprising:

supplying a first RF signal to a first electrode disposed in an etch chamber; and

supplying a second RF signal to the first electrode, wherein an interaction between the first and second RF signals is used to control at least one characteristic of a plasma formed in the etch chamber.

2. (Original) The method of claim 1, wherein the plasma characteristic is at least sheath modulation.

3. (Original) The method of claim 2, wherein the first and second RF signals are of a low enough frequency to provide a strong self-biasing sheath in the plasma.

4. (Original) The method of claim 2, wherein the first RF signal provides a broad ion energy distribution and the second RF signal provides a peaked, well defined ion energy distribution.

5. (Original) The method of claim 4, wherein the first RF signal has a cycle time that is larger than the transit time of an ion in the sheath, and wherein the second RF signal has a period that is nearly equal to or greater than the transit time of an ion in the sheath.

6. (Original) The method of claim 2, wherein the combined applied voltage of the first and second RF signal is used to control a peak-to-peak sheath voltage and a self-biased DC potential.

7. (Original) The method of claim 6, wherein the interaction between the first and second RF signals is a ratio of their applied power.

8. (Original) The method of claim 7, wherein the ratio is used to tune the energy distribution about an average acceleration generated by the DC potential.

9. (Original) The method of claim 1, further comprising:
supplying a third RF signal to a second electrode to form the plasma.

10. (Original) The method of claim 1, wherein the plasma characteristic is at least a power distribution within the plasma.

11. (Original) The method of claim 10, wherein the first and second RF signals provide similar plasma excitation properties and different spatial uniformity profiles.

12. (Original) The method of claim 11, wherein the interaction between the first and second RF signals is a varying effect on the power distribution in the plasma.

13. (Original) The method of claim 12, wherein the first and the second RF signals are selected such that a combined effect of the first and second RF signals produces a substantially flat power distribution.

14. (Original) The method of claim 12, wherein the interaction between the first and second RF signals is used to control the uniformity of a plasma enhanced etch process.

33. (Previously Presented) The method of claim 1, wherein the first RF signal has a frequency of about 2 MHz and the second RF signal has a frequency of about 13.56 MHz.

34. (Previously Presented) A method of controlling characteristics of a plasma in a semiconductor substrate etch chamber using a dual frequency RF source, comprising:
determining a desired energy distribution of the plasma; and

producing the desired energy distribution through a controlled interaction between a first and a second RF signal applied to a first electrode disposed in an etch chamber.

35. (Previously Presented) The method of claim 34, wherein the producing step further comprises:

supplying the first RF signal at a first power level; and

supplying the second RF signal at a second power level, the second power level at a predetermined ratio of the first RF signal.

36. (Previously Presented) The method of claim 34, wherein the first RF signal has a frequency of about 2 MHz and the second RF signal has a frequency of about 13.56 MHz.

37. (Previously Presented) A method of controlling characteristics of a plasma in a semiconductor substrate etch chamber using a dual frequency RF source, comprising:

supplying a first RF signal at a first power level to a first electrode disposed in an etch chamber; and

controlling the application of a second RF signal at a second power level to the first electrode to produce a desired power distribution in the plasma.

38. (Previously Presented) The method of claim 37, wherein the desired power distribution is substantially flat.

39. (Previously Presented) The method of claim 37, further comprising:

etching a substrate using the plasma having the desired power distribution.

40. (Previously Presented) The method of claim 1, wherein the first electrode is disposed beneath a substrate support surface in the etch chamber.

41. (Previously Presented) The method of claim 40, wherein the electrode is a cathode.

42. (Previously Presented) The method of claim 40, further comprising:
etching a substrate disposed on the substrate support surface.

43. (Previously Presented) The method of claim 34, wherein the first electrode is disposed beneath a substrate support surface in the etch chamber.

44. (Previously Presented) The method of claim 43, further comprising:
etching a substrate disposed on the substrate support surface.

45. (Previously Presented) The method of claim 37, wherein the first electrode is disposed beneath a substrate support surface in the etch chamber.

46 (Previously Presented) The method of claim 45, further comprising:
etching a substrate disposed on the substrate support surface.

EVIDENCE APPENDIX

[NONE]

RELATED PROCEEDINGS APPENDIX

[NONE]